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## ORIGINAL ARTICLE

# Maternal diabetes or hypertension and lifestyle factors may be associated with metabolic syndrome: A population-based study in Taiwan



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## KEYWORDS

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**Abstract** Early detection and interventions for metabolic syndrome (MetS) are the most cost-effective methods for preventing many chronic diseases. There have been discordant findings in various countries due to different genetics and lifestyles. The goal of this study was to investigate the association of MetS with parental diseases, a Chinese-style diet, and rural-urban regional differences with a large-scale epidemiological survey in Taiwan. Data were obtained from the Taiwanese Survey on Hypertension, Hyperglycemia, and Hyperlipidemia (TwSHHH), a cross-sectional population-based study with multistage stratified random sampling conducted by the Taiwan Bureau of Health Promotion in 2002. Public health nurses visited homes to conduct the survey, including blood drawing and an interview. Multiple logistic regression analysis was used for exploring the factors associated with MetS. A total of 6591 people completed

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data for analysis. Our results revealed that older age, male sex, and maternal diabetes or hypertension, were significantly associated with MetS. Eating poultry with skin and fat and eating a bean-free diet may be associated with a higher risk of MetS. People who exercised regularly and the residents of the Taipei metropolitan area had a lower prevalence of MetS. As a result, people with maternal diabetes or hypertension should pay attention to their cardiovascular health and prevention of MetS. We suggest that eating skinless and low-fat poultry, eating more beans, and exercising regularly, may decrease the risk of MetS. We should make an effort to advocate for health promotion, including lifestyle modification, especially among the high-risk population and among residents in rural areas with limited medical resources.

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## Introduction

Cardiovascular disease (CVD) is the chief cause of death around the world, which was identified by the World Health Organization (WHO) in 2008 [1]. The associated economic burden and social cost make it imperative to identify the risk factors and develop global strategies to reduce the incidence. Among patients with CVD, we found that many people had metabolic syndrome (MetS) before progressing to CVD. MetS, a collection of metabolic disorders, including obesity, insulin resistance, dyslipidemia, and hypertension, is regarded as the prodromal stage of CVD and type 2 diabetes mellitus (DM), and it also contributes to increased all-cause mortality [2,3]. It is more valuable to identify individuals with an elevated risk of MetS and give them education and early interventions prior to the development of disease.

Although many authors have researched the impact of parental hypertension, diabetes, dyslipidemia, and MetS on offspring [4–6], paternal and maternal histories were discussed separately in prior studies, to elucidate the unequal impact of parents; however, the discordant findings elicited our interest for further investigation. A higher risk from maternal transmission of type 2 DM was reported [7,8] but not observed in all studies [9,10]. The Framingham offspring study proposed that offspring with maternal diabetes had a higher odds ratio of abnormal glucose tolerance, but no higher risk of DM was observed [11]. Regarding the association of parental diseases with MetS, Liese et al [12] demonstrated that parental diabetes and hypertension had a dose-response relationship with the odds of MetS; by contrast, Rodriguez-Moran and Guerrero-Romero [13] proposed that parental diabetes would increase the risk of MetS in Mexican individuals, whereas parental hypertension did not. We suppose that ethnic differences may partially explain the inconsistent results. Therefore, we conducted this study in order to gather information from an Asian population. Although parental disease histories are unchangeable, we can determine the high-risk population with maternal diabetes or hypertension and remind them to pay attention to health condition and lifestyle in order to prevent MetS in Taiwan.

Dietary habits have a great impact on health. According to prior literature, a Mediterranean diet and the Dietary Approaches to Stop Hypertension (DASH) diet may reduce the risk of MetS [14,15], while a Western diet and a diet

with a high-glycemic-load may increase the risk [16,17]. With the different cultural and economic backgrounds of various countries, residents of each country have their own specific diet patterns. Most Chinese people eat stir-fried vegetables instead of salad, and they prefer to eat meat with skin and fat. In Taiwan, many people like to add gravy on rice or use lard in cooking to promote flavor. The correlation between the Chinese-style diet and MetS remains unclear.

Rural-urban disparities in health status and disease prevalence have emerged as compelling issues for governments and public health professionals. Rural dwellers of some developed countries tend to have a poorer health status and a higher prevalence of obesity, possibly due to unhealthy behavior, less nutritious food, and less exercise [18,19]. On the contrary, in some developing countries, urban populations have a higher prevalence of obesity and MetS, which may be attributable to higher dietary fat ingestion and less physical activity [20–22]. Based on the Nutrition and Health Surveys in Taiwan (NAHSIT), the growing trends in obesity and MetS have slowed in the most urbanized northern area in recent years, but the prevalence in central and southern areas was still rapidly increasing [23]. This regional difference in Taiwan drew our attention.

Although numerous studies about MetS have been conducted, there is little information about the associated risk factors of MetS in the Asian population, especially in Taiwan. Thus, the goal of this study was to investigate the association between MetS and parental diseases, a Chinese-style diet, and rural-urban regional difference with a large-scale epidemiological survey in Taiwan.

## Methods

### Study population and measurements

The data for our study were obtained from the Taiwanese Survey on Hypertension, Hyperglycemia, and Hyperlipidemia (TwSHHH), a cross-sectional study performed by the Taiwan Bureau of Health Promotion from March to October 2002. The participants of this nationwide study were citizens > 15 years old, selected by a multistage stratified random sampling, which has been described in previous articles [24,25]. The selection design was briefly

summarized: (1) 359 townships were divided into seven strata according to geographic location, and 88 townships were randomly selected; (2) with a sampling rate proportional to size, 8–44 lins (administrative units, smaller than towns) were selected from the 88 townships; (3) four households were randomly selected from the lins, and thus, 6592 households from 1648 lins were selected, yielding about 26,368 participants; and (4) on the basis of economical principle, we reduced the number of participants by randomly selecting one half of the lins again.

Finally, 10,292 people from 824 lins were selected. The selected list of study participants was sent to well-trained public health nurses, who telephoned them to make an appointment for a face-to-face questionnaire interview, blood pressure measurement, and blood sampling. The completion rate is 73.6%, 67.4%, and 64.1%, respectively. Finally, we obtained 6591 complete data (64.1%) for analysis.

Blood sampling for biochemical analyses, including fasting blood sugar, glycosylated hemoglobin (HbA1c), cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglyceride (TG), apolipoprotein-A1 (ApoA1), apolipoprotein-B (ApoB), aspartate aminotransferase (AST), alanine aminotransferase (ALT), blood urea nitrogen (BUN), creatinine, and uric acid (UA).

Blood pressure (BP) was measured at the interview with a calibrated mercury sphygmomanometer in the right arm after 5–10 minutes of rest. A third BP was checked if the difference between the first two measurements was  $>10$  mmHg. The average of the two closest numerals was regarded as the final BP. Waist circumference (WC) was measured at a level midway between the lowest rib and the iliac crest, and hip circumference (HC) was measured around the maximum circumference of the buttocks in the standing position, with the tape placed parallel to the floor. The waist-to-hip ratio (WHR) was defined as the ratio of WC to HC.

At the interview, information about family history, life-style, and medical history was collected by nurses using questionnaires. Parents' medical histories of DM and hypertension were recorded if they had been diagnosed by a doctor. Regular exercise was defined as activity performed  $>$ three times a week,  $>$  30 minutes each time, reaching more than 130 heart beats/minute, with persistent exercise habits for at least 3 months. However, the detailed types of exercise and leisure activity were not included in the questionnaire. Dietary habits were assessed with a series of questions, including cooking technique and some specialized Chinese-style foods, such as eating livestock or poultry with fat or skin, eating beans, using gravy or lard, and cooking food by frying. The variety of food items was limited. Fat-rich food intake was regarded as eating meat with skin or fat, fried vegetables, fried meat, and fried fish. Cooking techniques of frying included pan-fry, stir-fry, and deep-fry. Beans included peas, soybeans, tofu, and others. The detailed food items were not included in the questionnaire of TwSHHH 2002. The answers were recorded as the frequency of consumption in the past year: always, most of the time, half of the time, seldom, never, or do not eat this food. Any dietary habit recorded as half of the time

or more (always, most, and half of the time) was defined as 'frequently eat'.

## Definition of MetS

Based on the revised NCEP-ATP III (National Cholesterol Education Program - Adult Treatment Panel III), the Taiwan Bureau of Health Promotion modified the definition of MetS for Taiwanese in 2007, and individuals with at least three of the following criteria are diagnosed with MetS: (1) WC  $\geq 90$  cm in men, WC  $\geq 80$  cm in women; (2) systolic BP  $\geq 130$  mmHg or diastolic BP  $\geq 85$  mmHg, or current use of antihypertensive medication; (3) fasting plasma glucose  $\geq 100$  mg/dL, or current use of antidiabetic medication; (4) HDL  $< 40$  mg/dL in men, HDL  $< 50$  mg/dL in women; and (5) fasting TG  $\geq 150$  mg/dL.

## Statistical analyses

Data were analyzed with IBM SPSS version 19.0 (IBM inc., Armonk, NY, USA). We used a Chi-square test and a Student *t* test to compare the difference between the MetS group and the non-MetS group. Multiple logistic regressions were used to analyze the association between MetS and dietary habits, first with adjustment for potential confounders. Then, the association between MetS and paternal and maternal histories of DM and hypertension was analyzed separately, with adjustment for significant dietary habits, regular exercise, and residency in the Taipei metropolitan area, age, and sex. Finally, a multiple logistic regression was used to analyze the combined parental histories of DM and hypertension associated with MetS with adjustment for potential confounders. Two-tailed  $p < 0.05$  was considered significant.

## Results

Among the 6591 participants with adequate data, 1132 (17.2%) fit the criteria for MetS, and their demographic characteristics were compared with the non-MetS individuals in Table 1. More male participants (19.2%) than female participants fit the criteria for MetS. The participants with MetS were more likely to have a mother with chronic diseases (19.3%), including diabetes or hypertension.

Table 2 shows the comparison of physical and biochemical parameters between MetS and non-MetS individuals. Those with MetS were older ( $53.52 \pm 15.32$  vs.  $40.85 \pm 16.36$  years,  $p < 0.001$ ), with higher systolic BP and diastolic BP, and larger WC, HC, and WHR ( $0.90 \pm 0.07$  vs.  $0.81 \pm 0.08$ ,  $p < 0.001$ ). With regard to biochemical parameters, the individuals with MetS had higher HbA1c, cholesterol, LDL-C, ApoB, AST, ALT, BUN, creatinine, and UA; however, they had lower ApoA1.

Table 3 shows the summary of odds ratios (OR) for MetS associated with dietary habits. People who frequently ate livestock (OR = 1.15, 95% CI = 1.00–1.32,  $p < 0.05$ ) or poultry with skin or fat (OR = 1.23, 95% CI = 1.07–1.41,  $p < 0.01$ ) had a higher risk of MetS. People who ate no beans also had a higher OR of MetS (OR = 1.91, 95% CI = 1.23–2.97,  $p < 0.01$ ). In contrast, frequently eating

**Table 1** Comparison of demographic characteristics between the metabolic syndrome (MetS) group and the non-MetS group.

	MetS (n = 1132)	Non-MetS (n = 5459)	p*
Sex			<0.001
Male	608 (19.2%)	2554 (80.8%)	
Female	524 (15.3%)	2905 (84.7%)	
Residential area			0.090
Taipei metropolitan area	308 (16.0%)	1623 (84.0%)	
Other areas	824 (17.7%)	3836 (82.3%)	
Paternal history of chronic diseases <sup>a</sup>			0.455
Yes	326 (16.6%)	1633 (83.4%)	
No	806 (17.4%)	3826 (82.6%)	
Maternal history of chronic diseases <sup>a</sup>			0.001
Yes	417 (19.3%)	1741 (80.7%)	
No	715 (16.1%)	3718 (83.9%)	
Exercise regularly			0.420
Yes	261 (16.5%)	1320 (83.5%)	
No	871 (17.4%)	4139 (82.6%)	

\*Chi-square test.

<sup>a</sup> Paternal and maternal history of chronic diseases: diabetes mellitus, hypertension.

fried vegetables, fried meat, fried fish and egg yolks, using lard and gravy, and eating dark-green vegetables both at lunch and dinner had no significant impact on MetS.

Table 4 shows the adjusted OR for MetS associated separately with the paternal and maternal histories of DM and hypertension. We found that mothers with hypertension only (OR = 1.37, 95% CI = 1.14–1.64), mothers with diabetes only (OR = 1.70, 95% CI = 1.31–2.20), and mothers with both hypertension and diabetes (OR = 2.03, 95% CI = 1.54–2.68) had significantly higher impacts on MetS in offspring. In contrast, there was no significant finding in the paternal model. Besides, Taipei metropolitan residents had a lower risk in the maternal model (OR = 0.84). Regular exercise was negatively associated with MetS (OR = 0.80 in the paternal model, OR = 0.79 in the maternal model). With regard to dietary habits, frequently eating poultry with skin or fat (OR = 1.19 in the paternal model, OR = 1.21 in the maternal model), and eating a diet without beans (OR = 1.94 in the paternal model, OR = 1.96 in the maternal model) were positively associated with MetS.

Fig. 1 lists the ORs obtained from a multiple logistic regression that analyzed the combined parental histories of DM and hypertension associated with MetS with adjustment for potential confounders. The first cluster (groups A, B, C) included those with a healthy mother and a father with hypertension (C), a father with DM (B), or a father with both DM and hypertension (A). ORs were not significant, compared to the reference, whose father and mother were both healthy. Cluster 2 (groups D, E, F) included those with a healthy father and a mother with both DM and hypertension (D, OR = 2.14, 95% CI = 1.52–3.02), a mother with

**Table 2** Comparison of physical and biochemical parameters between the metabolic syndrome (MetS) group and the reference group, presented as mean (SD).

	MetS (n = 1132)	Non-MetS (n = 5459)	p*
Age (y)	53.52 (15.32)	40.85 (16.36)	<0.001
HC (cm)	102.21 (8.35)	95.31 (7.43)	<0.001
WHR	0.90 (0.07)	0.81 (0.08)	<0.001
HbA1c (%)	6.15 (1.63)	5.20 (0.80)	<0.001
Cholesterol (mg/dL)	200.94 (44.15)	179.72 (35.40)	<0.001
LDL (mg/dL)	129.22 (29.07)	112.31 (25.88)	<0.001
ApoA1 (mg/dL)	138.46 (25.20)	145.28 (24.79)	<0.001
ApoB (mg/dL)	107.06 (26.65)	84.83 (23.30)	<0.001
AST (IU/L)	25.85 (26.32)	19.97 (14.45)	<0.001
ALT (IU/L)	24.71 (18.26)	19.47 (15.29)	<0.001
BUN (mg/dL)	15.60 (6.08)	13.84 (4.13)	<0.001
Creatinine (mg/dL)	0.98 (0.48)	0.90 (0.28)	<0.001
UA (mg/dL)	7.15 (1.94)	6.19 (1.73)	<0.001
WC (cm)	91.69 (8.96)	77.27 (10.17)	<0.001
Systolic BP (mmHg)	132.35 (18.40)	111.99 (15.92)	<0.001
Diastolic BP (mmHg)	84.35 (11.00)	72.98 (10.31)	<0.001
Fasting sugar (mg/dL)	117.46 (49.00)	89.66 (19.20)	<0.001
HDL (mg/dL)	44.78 (15.37)	57.39 (13.98)	<0.001
Triglyceride (mg/dL)	228.93 (120.43)	106.14 (57.70)	<0.001

\*Analyzed by *t* test.

ALT = alanine aminotransferase; ApoA1 = apolipoprotein-A1; ApoB = apolipoprotein-B; AST = aspartate aminotransferase; BP = blood pressure; BUN = blood urea nitrogen; HbA1c = glycosylated hemoglobin; HC = hip circumference; HDL = high-density lipoprotein cholesterol; LDL = low-density lipoprotein cholesterol; UA = uric acid; WC = waist circumference; WHR = waist-to-hip ratio.

DM only (E, OR = 1.66, 95% CI = 1.21–2.28), or a mother with hypertension only (F, OR = 1.28, 95% CI = 1.02–1.60). For the third cluster, groups G to O, compared to those with a father and mother who were both healthy, the ORs were varied and complicated because some groups had small numbers (for group H, the participants with a mother with DM only and a father with both DM and hypertension, *n* = 13; for group J, the participants with a mother with both DM and hypertension and a father with DM only, *n* = 15). However, many ORs of combinations of parental DM and hypertension histories were large and significant (Fig. 1).

## Discussion

Our study demonstrated several risk factors for MetS in Taiwan. In the nationwide population-based survey, older age, male sex, maternal diabetes or hypertension, a diet including livestock or poultry with skin or fat, and a bean-free diet were predisposing factors for MetS. In contrast,



**Table 3** Summary of odds ratios (OR) of metabolic syndrome associated with dietary habits using logistic regressions adjusted for age and sex.

Dietary habits	n	OR (95% CI)
Frequently eat livestock with skin or fat	2730	1.15 (1.00–1.32)*
Frequently eat poultry with skin or fat	3403	1.23 (1.07–1.41)**
Frequently eat fried vegetables	6245	1.03 (0.78–1.36)
Frequently eat fried meat	4514	1.01 (0.87–1.17)
Frequently eat fried fish	5511	1.02 (0.85–1.22)
Frequently eat eggs with yolk	5920	0.83 (0.67–1.02)
Use lard in cooking	1582	1.02 (0.87–1.21)
Add gravy on rice or noodles	996	1.15 (0.96–1.38)
Eat dark-green vegetables at both lunch and dinner	6082	1.01 (0.78–1.30)
Eat a no-bean diet	97	1.91 (1.23–2.97)**

\* $p < 0.05$ .\*\* $p < 0.01$ .

Each analysis with multiple regressions adjusted for age and sex.

people who exercise regularly and residents of the Taipei metropolitan area had a lower prevalence of MetS.

Among the parental diseases, maternal diabetes had the largest impact on the occurrence of MetS in the offspring in our study, and maternal hypertension had the second-largest impact. Some authors have tried to clarify the parent-offspring correlations for metabolic disorders, but discordant results were obtained [12,13]. One study in Brazil proposed that maternal type 2 DM might add to the risk of type 2 DM for offspring, but no increased prevalence of MetS was observed [26]. We suppose that ethnic

differences may partially explain the inconsistent results. However, many prior studies emphasized excess maternal transmission of type 2 DM [7, 8]. Additionally, mitochondrial DNA variant is also likely to increase the risk of MetS [27,28]. According to most literature and our findings, we suggest that maternal inheritance may play a major role in the diseases of offspring.

Many theories have been proposed to interpret the subtle inheritance pattern of higher maternal influence, but the exact mechanism of how genetic transmission affects the offspring remains unclear. The intrauterine environment, genomic imprinting, and mitochondrial inheritance may contribute to maternal inheritance [4,7]. Another possible explanation is that the mother has more time to care for and accompany the offspring compared to the father, resulting in a greater sharing of environment and diet [7]. In fact, the etiology of these metabolic disorders is multifactorial, involving not only genetic inheritance, but also environmental factors, and it is difficult for us to evaluate the two factors separately.

Our study revealed that people who frequently eat livestock or poultry with skin and fat have a higher risk of MetS. Western people prefer to eat red meat, hamburger, and bacon, which are risk factors for MetS and type 2 DM [29]. Unlike western people, most Chinese people prefer to eat meat with skin and fat, such as Dong-Po pork, stewed pig feet, and Peking duck. The skin and fat of livestock or poultry are abundant in cholesterol and saturated fatty acids, which may contribute to dyslipidemia. Skinless poultry was recommended in the European Society of Cardiology (ESC) and the European Atherosclerosis Society (EAS) guidelines, to lower cholesterol and LDL-C [30], but there have not been any specific data to elucidate the relationship between poultry skin and diseases. Our results show a higher risk of MetS for people who frequently eat meat with skin and fat and a lower risk for those who seldom or never eat poultry with skin and fat. Therefore,

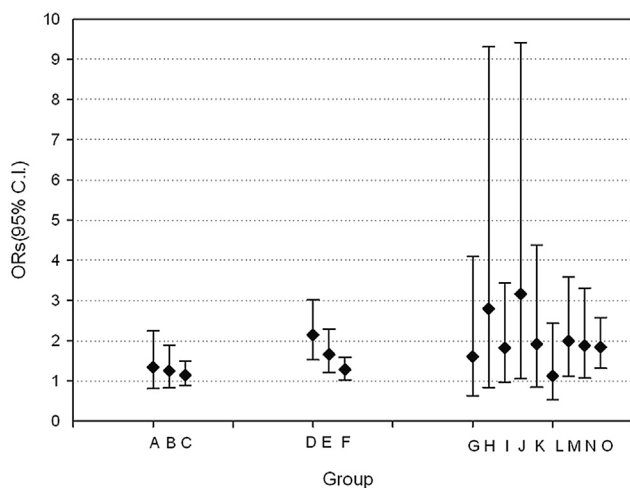
**Table 4** Logistic regression for metabolic syndrome and its association with parental diabetes and hypertension histories and other affecting factors.

Variables	Model 1		Model 2	
	OR	(95% CI)	OR	(95% CI)
Age	1.046	(1.042–1.051)**	1.048	(1.043–1.052)**
Sex				
Male	1.290	(1.123–1.481)**	1.297	(1.129–1.489)**
Residential area				
Taipei Metropolitan	0.867	(0.746–1.008)	0.844	(0.726–0.982)*
Exercise habits	0.800	(0.682–0.940)**	0.790	(0.673–0.928)**
Frequently eat livestock with skin and fat	1.025	(0.863–1.219)	1.026	(0.863–1.220)
Frequently eat poultry with skin and fat	1.191	(1.003–1.415)*	1.207	(1.016–1.434)*
Eat a no-bean diet	1.937	(1.247–3.009)**	1.959	(1.262–3.041)**
Without DM HTN <sup>a</sup>	1.000		1.000	
With HTN only <sup>a</sup>	1.032	(0.827–1.289)	1.367	(1.140–1.640)**
With DM only <sup>a</sup>	0.992	(0.708–1.390)	1.696	(1.306–2.203)**
Both DM HTN <sup>a</sup>	1.335	(0.852–2.090)	2.029	(1.537–2.679)**

\* $p < 0.05$ .\*\* $p < 0.01$ .

CI = confidence interval; DM = diabetes mellitus; HTN = hypertension; OR = odds ratio.

<sup>a</sup> Model 1: Paternal disease history; Model 2: Maternal disease history.



**Figure 1.** Odds ratios (ORs) and 95% confidence intervals (CIs) from a multiple logistic regression analyzing metabolic syndrome and its association with the combined parental histories of diabetes mellitus (DM) and hypertension, with adjustment for age, sex, area of residence, exercise habits, and significant dietary habits. Cluster 1: group A, healthy mother and father with both DM and hypertension; group B, healthy mother and father with DM only; group C, healthy mother and father with hypertension only. Cluster 2: group D, healthy father and mother with both DM and hypertension; group E, healthy father and mother with DM only; group F, healthy father and mother with hypertension only. Cluster 3: group G, both father and mother with both DM and hypertension; group H, mother with DM only and father with both DM and hypertension; group I, mother with hypertension only and father with both DM and hypertension; group J, mother with both DM and hypertension and father with DM only; group K, both mother and father with DM only; group L, father with DM only and mother with hypertension only; group M, father with hypertension only and mother with both DM and hypertension; group N, father with hypertension only and mother with DM only; group O, both mother and father with hypertension only.

we can make a convincing argument to persuade people to eat skinless and low-fat meat.

Beans, rich in many nutrients and bioactive flavonoids, have been regarded as a healthy food. Many soy products, such as tofu, natto, and soybean milk, have particular values in Eastern countries. Prior studies showed that bean consumers had a lower risk of obesity, central adiposity, and ischemic heart disease [31,32]. The data from NHIS 2001 in Taiwan demonstrated that a bean-free diet might increase the risk of MetS, a finding that is similar to ours [33].

Our study indicated that the residents of the Taipei metropolitan area had a significantly lower risk of MetS. In some developing countries, an increasing burden of MetS and obesity was observed among urban dwellers and people with high socioeconomic status, due to less physical activity and higher dietary fat ingestion [20–22, 34]. Nevertheless, this epidemiological transition may vary by country and residential environment. The prevalence of obesity and DM was higher in high-poverty areas in the U.S.A and rural

women of Australia, possibly attributable to fewer facilities for physical activity and poorer access to health care providers [35,36]. In Taiwan, the Taipei metropolitan area is the largest city and is the capital of Taiwan, with the highest socioeconomic and cultural level. According to the survey, Taipei residents engaged in the most frequent physical activity, and they also had a lower prevalence of obesity. Therefore, we assumed that they concentrate on personal health, participate in more health-promotion programs, and avoid unhealthy behaviors, to prevent the development of diseases. In addition, compared with the rest of Taiwan, the number of physicians per capita is the highest in Taipei [37], and the proximity to medical services may also contribute to public health.

The large sample size and stratified random sampling strategy may represent the national population and were the strengths of this study. First, a lack of data on the participants' body weight and height was one of our limitations. However, the definition of MetS utilizes WC, not body weight, as one of the criteria. In addition, TwSHHH measured waist and HC as the indicator of obesity, which has been assumed to be better than BMI to predict vascular risk in the literature [38,39]. Second, information about some personal habits that are possible risk factors for MetS, such as smoking, drinking alcohol, and betel-nut chewing, was also unavailable. Third, recall bias may exist because the history of parental diseases was obtained from the offspring's statement. However, well-trained public health nurses interviewed the participants and confirmed that parental diabetes and hypertension were diagnosed by physicians. The validation of the questionnaire would reduce the bias. Last, because we wanted to investigate the impact of a Chinese-style diet and cooking techniques, the TwSHHH devised the questionnaire with an emphasis on the specified food items, not including fruits, milk, and dairy products. In addition, the study measured ingestion frequency in daily life instead of exact food serving sizes. In fact, it is difficult to quantify Chinese dishes, but there existed an advantage owing to the double-blind study design, so this factor was unlikely to affect the results. The TwSHHH was a governmental research with a validated questionnaire design and quality control. The accomplished questionnaire was examined to exclude unreasonable and incomplete data. Five percent of the participants were selected for recheck on telephone by another nurse, who was blind to the original answers. Therefore, the results of questionnaires were reliable.

In conclusion, we found that maternal diabetes or hypertension plays a major role in MetS for offspring. We suggest that eating skinless poultry and lean meat, eating more beans, and exercising regularly may decrease the risk of MetS. The residents of the Taipei metropolitan area have a lower prevalence of MetS than residents of other areas, which may provide an incentive for the governmental authorities to advocate for health promotion and improve the availability of medical resources in remote areas.

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